ELECTROCHEMICAL TESTS OF CoCr ALLOY MADE WITH ADDITIVE TECHNOLOGY

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Introduction

One of the methods of treatment of missing human teeth without the necessity of the placement of dental implants is the use of a metal frame removable partial dentures. It allows to restore the aesthetics and functionality of the stomatognathic system to patients who, among others they feel anxiety about implantation or are facing bone atrophy. The use of a prosthesis also significantly reduces the cost of treatment compared to implants [1]. The introduction of 3D printing technology has caused this method to be applicable also in the manufacture of frames [2]. Although frames made with this technology are better suited to the patient's anatomical features, the method of surface preparation is still a challenge, if only because of their complicated shape. When designing the final form of the surface layer for this type of products made using 3D printing, it is necessary to take into account, first of all, the morphology of the substrate, as well as the conditions in which it will function in the human mouth [3].

Materials and Methods

CoCr alloy samples made using the classic technique (casting) and using additive technology were selected for the tests - 3D printing after electrochemical polishing with parameters that allow obtaining a surface roughness Ra <0.3 µm. The potentiodynamic tests were carried out as recommended by the ASTM F2129 standard. Potentiodynamic studies were performed using a potentiostat PGP-201 Radiometer Analytical SAS. As reference electrode a saturated calomel electrode NEK KP-113 was used, and as the auxiliary electrode - platinum PTP-201. To determine the values characterizing the corrosion resistance of tested samples, Stern method was applied. EIS measurements were performed using a potentiostat AutoLab PGSTAT 302N along with a set of electrodes provided with the module FRA2 (Frequency Response Analyser). The measuring system that was used during the study enables research in the frequency range $10^4 \div 10^{-3}$Hz. The voltage amplitude of the sinusoidal excitation signal was 10 mV.
The tests were carried out in artificial saliva at a temperature of T = 37 ± 1°C.

Results and Discussion

The examples of polarization curves recorded for the CoCr alloy are shown in FIG. 1. The values of corrosion potential, polarization resistance and transpassivation potential determined on their basis clearly showed better pitting corrosion resistance of the CoCr alloy made by 3D printing - TABLE 1.
In turn, the tests carried out using electrochemical impedance spectroscopy confirmed the results obtained in potentiodynamic tests. On the surface of the CoCr alloy made by 3D printing, the presence of a double layer with better electrochemical properties in relation to the oxide layer formed on the surface of the cast CoCr alloy was shown - TABLE 2.

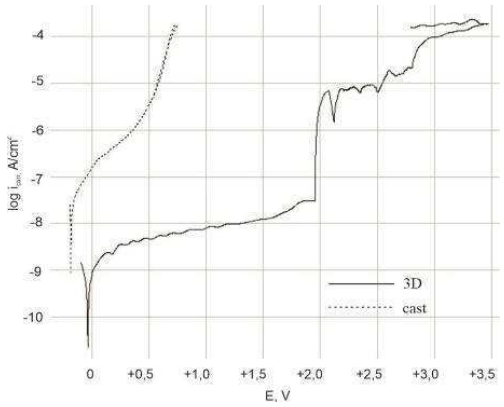

FIG. 1. Examples of polarization curves for CoCr alloy.

TABLE 2. Results of potentiodynamic test.

CoCr alloy	E_{corr}, mV	E_{tr}, mV	Rp, kΩcm^2
3D printing	-32	+1 950	3 081
cast	-189	+650	53

The best fit of the model spectra to the impedance spectra determined experimentally in artificial saliva is provided by the circuits shown in FIG. 2.

FIG. 2. Electrical model of equivalent circuit for CoCr alloy – artificial saliva: a) 3D printing, b) cast.

TABLE 2. Results of EIS.

CoCr alloy	R_s, Ω·cm^2	R_p, kΩ·cm^2	CPE_p		R_{ct}, kΩ·cm^2	CPE_{dl}	
			Y_0, $\Omega^{-1}cm^{-2}s^{-n}$	n		Y_0, $\Omega^{-1}cm^{-2}s^{-n}$	n
3D printing	53	201	0,2121E-4	0,9	1 908	0,2367E-4	0,9
cast	52	-	-	-	655	0,8984E-4	0,9

Conclusions

Based on the conducted electro-chemical tests, it was found that 3D printing technology is a more preferred method of manufacturing a metal frame of dentures made of CoCr alloy. Corrosion resistance in the environment of artificial saliva for this type of technology is higher in comparison with products made of CoCr alloy using classic technology (casting). In addition, proposing suitable surface treatment variants for CoCr alloy products made with this technology is of prospective importance and will contribute to the development of technological conditions that allow obtaining antibacterial and anti-fungal coatings.

References

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